IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Mark W. Wanlass, et al.	) Group Art: 1722
Serial No.:	10/526,785	) Examiner: SONG, Matthew J.
Filed:	March 4, 2005	) Atty. Dkt. No. NREL 02-01
Title:	Method For Achieving Device-Quality Active Layers in Lattice- Mismatched, Epitaxial Heterostructures	)

APPEAL BRIEF

To: MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

As required under 37 C.F.R. §41.37(a), this brief is filed within two months of the Notice of Appeal filed in this case on June 16, 2008, and is in furtherance to the Notice of Appeal.

This brief contains items under the following headings as required by 37 C.F.R. §41.37 and M.P.E.P. §1206:

I. Real Party In Interest
II. Related Appeals, Interferences, and Judicial Proceedings
III. Status of Claims
IV. Status of Amendments
V. Summary of Claimed Subject Matter
VI. Grounds of Rejection to be Reviewed on Appeal
VII. Argument
VIII. Claims Appendix
IX. Evidence Appendix
X. Related Proceedings Appendix

I. REAL PARTY IN INTEREST

The real party in interest for this appeal is the Midwest Research Institute, having its principal place of business at 425 Volker Boulevard, Kansas City, Missouri 64110.

The United States Government also has rights in this invention under Contract No. DE-AC36-99GO10337 between the United States Department of Energy and the National Renewable Energy Laboratory, a division of the Midwest Research Institute.

II. RELATED APPEALS, INTERFERENCES, AND JUDICIAL PROCEEDINGS

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

A. Total Number of Claims in Application

There are 30 claims pending in this application (Claims 1-30).

B. Current Status of Claims

1. Claims canceled: None
2. Claims withdrawn from consideration but not canceled: None
3. Claims pending: 1-30
4. Claims allowed: None
5. Claims rejected: 1-30

C. Claims on Appeal

The claims on appeal are claims 1-30.

IV. STATUS OF AMENDMENTS

Appellant last amended the claims in a Request for Continued Examination filed on June 27, 2007. Therefore the claims on appeal (as reflected in the claim appendix) are the claims presented in the Request for Continued Examination filed on June 27, 2007, which has already been entered.

V. SUMMARY OF CLAIMED SUBJECT MATTER

According to claim 1, a heterostructure (FIGS. 1 and 6) containing semiconductor alloys for minimizing dislocations resulting from lattice mismatch of an active, heteroepitaxial layer. The heterostructure comprises a substrate (12 in FIG. 1; p. 6, ll. 5-6 and 21-23), a compositionally graded region terminated by a strained buffer layer (14 in FIG. 1; p. 11, ll. 10-13; p. 12, ll. 1-8), a relaxed intermediate region (16 in FIG. 1; p. 11, ll. 13-15; p. 12, ll. 13-15; p. 14, ll. 5-6), an active layer (18 in FIG. 1; p. 11, ll. 6-7; p. 12, ll. 9-12), and a capping layer (20 in FIG. 1; p. 6, ll. 13-14; p. 11, l. 16). In the active layer, a lattice constant of the buffer layer parallel to the substrate is matched to a lattice constant of the relaxed intermediate region to discourage glide of threading dislocations from the strained buffer layer to the active layer (p. 4, ll. 16-23).

According to claim 13, a method for eliminating strain and dislocations resulting from lattice mismatch of a heteroepitaxial layer (p. 4, ll. 10-11). The method comprises providing a substrate (p. 4, ll. 11-12; p. 6, ll. 5-6 and 21-23), depositing a compositionally graded region on the substrate (p. 6, ll. 9-10; p. 11, ll. 10-13; p. 12, ll. 1-3), terminating the graded region with a buffer layer (p.12, ll. 4-8), depositing a relaxed intermediate region on the buffer layer (p. 4, ll. 13-14; p. 11, ll. 13-15), depositing an active layer on the relaxed intermediate region such that a lattice constant of the buffer layer parallel to the substrate is matched to a lattice constant of the relaxed intermediate region to discourage glide of threading dislocations from the strained buffer layer to the active layer (p. 4. ll. 14-23), and depositing a capping layer on the active layer (p. 4, ll. 14-15; p. 6, ll. 13-14; p. 11, l. 16).

The summary is set forth in an exemplary embodiment that corresponds to the independent claims. It is noted that no dependent claims containing means plus function are argued separately. Discussions about elements and recitations to this claim can be found at least at the cited locations in the specification and drawings.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The Office Action dated March 17, 2008, independently rejected claims 26 and 30 and claims 1-30 under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement. The Office Action also rejected claims 26 and 30 under 35 U.S.C. 112, second paragraph, as failing to distinctly claim the subject matter which applicant regards as the invention. The Office Action also rejected claims 1-25 and 27-29 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,518,934 to Forrest et al. ("Forrest") in view of U.S. Patent No. 6,229,152 to Dries et al. ("Dries"). Finally, the Office Action rejected claims 26 and 30 under 35 U.S.C. § 103(a) as being unpatentable over Forrest in view of Dries and further in view of U.S. Patent No. 6,350,993 to Chu et al. ("Chu"). Appellant requests the Board to review each of these grounds of rejection.

VII. ARGUMENT

Rejections under 35 U.S.C. 112

Claims 26 and 30 stand rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. In particular, the Office Action states that there is no support for the term "compositional overshoot."

Claims 26 and 30 also stand rejected under 35 U.S.C. 112, second paragraph, as failing to distinctly claim the subject matter which applicant regards as the invention. In particular, the Office Action states that it is unclear what is intended to be "shot" to determine what would "overshoot."

Claims 1-30 stand under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. In particular, the Office Action states that "there is no support for 'discourage glide of threading dislocations'" and "[t]here is no support for the lattice constant of the buffer layer being matched to the relaxed

intermediate region" in claims 1 and 13, and that claims 2-12 and 14-30 depend from claims 1 and 13, respectively.

It is well settled that subject matter of the claim need not be described literally (i.e., using the same terms or in haec verba) in order for the disclosure to satisfy the description requirement. MPEP 2163.02. Instead, the fundamental factual inquiry is whether the specification conveys with reasonable clarity to those skilled in the art that, as of the filing date sought, applicant was in possession of the invention as now claimed. MPEP 2163.02 citing Vas-Cath, Inc. v. Mahurkar, 935 F.2d 1555, 1563-64, 19 USPQ2d 1111, 1117 (Fed. Cir. 1991). An applicant may rely on, among other things, words, structures, figures, diagrams, and formulas that fully set forth the claimed invention. MPEP 2163.02 citing Lockwood v. American Airlines, Inc., 107 F.3d 1565, 1572, 41 USPQ2d 1961, 1966 (Fed. Cir. 1997).

Dependent Claims 26 and 30

Support for the recitations "compositional overshoot" is found in the specification, e.g., at page 13, lines 4-6 and page 14, lines 1-3, discussing lattice mismatch f which term is interchangeable with composition.

Support is also found at least in the drawings as originally filed. Figure 5 is a graph of idealized misfit profiles for an optimized DH showing the bulk, unstrained misfit for the fully relaxed layers, and the strained, in-plane misfit as functions of position with respect to the substrate surface using the optimized heterostructure design. See, e.g., description of Figure 5 on page 5 of the specification. Specifically, the bulk misfit difference Δf shown in Figure 5 represents the compositional overshoot. It is noted that f is defined in terms of unstrained lattice constants, which in turn, are determined by Vegard's Law from composition (Vegard's Law states that the lattice constant of a semiconductor alloy is determined by the sum of the constituent lattice constants each weighted by their compositional fraction). See Equation 1 on page 2, which defines f in terms of the lattice constants of the substrate and an overgrown layer. The difference in bulk misfit Δf is clearly illustrated between the transition step graded region (e.g., at n=9) and the intermediate region.

Furthermore, Figure 6 is a schematic diagram illustrating a strained buffer layer providing a lattice-matched template for the coherent growth of an unstrained active layer. An intermediate region is inserted between the step-graded and active regions for structural isolation. The thin, cross-hatched lines represent crystallographic planes. The partially coherent interface structure below the buffer layer has been simplified for clarity. Relevant parametric relationships corresponding to various layers and interfaces are listed to the right of the diagram. See, e.g., description of Figure 6 on page 5 of the specification. Specifically, the compositional overshoot of the buffer layer (step n) is illustrated by the grids representing atomic planes in the buffer region. The grids in the buffer region are "stretched" relative to the grids shown in the underlying graded region (step n-1) and match the grids in the intermediate and active regions.

For at least the foregoing reasons, the Examiner has failed to establish that claims 26 and 30 fail to comply with the written description requirement.

In addition, it is well known that the term "overshoot" means 'to exceed' or to 'shoot beyond or over (a target).' See, e.g., Webster's Dictionary definition. Hence in the context of the claims, "wherein the buffer layer is a compositional overshoot," clearly means that the buffer layer exceeds or is beyond a target size of the buffer layer (compared to "standard practice," where the unstrained lattice constants, based on composition, of the buffer layer and an over-layer, are matched). Furthermore, the specification describes "standard practice" on page 2, lines 2-5. The term "overshoot" relates to the composition compared to the standard practice to achieve in-plane lattice matching. See, also, page 3, lines 14-15.

For at least the foregoing reasons, the Examiner has failed to establish that claims 26 and 30 are indefinite.

Independent Claims 1 and 13

Support for the recitations "discourage glide of threading dislocations" is found in the specification at least on page 1, lines 13-15; on page 3, lines 24-26; on page 4, lines 18-21. Additional support is found on page 12, lines 13-15 which explains that the displacement layer is defined as unstrained, and those having

ordinary skill in the art know that strain drives dislocation glide. Therefore, an unstrained displacement (intermediate) layer will discourage threading dislocation glide from the buffer layer through to the active layer. Further support is found on page 14, lines 5-6 which defines the InAsP displacement layer as unstrained. See also Figures 5 and 6.

Support for the recitations "the lattice constant of the buffer layer being matched to the relaxed intermediate region" is found at least on page 5, lines 24-26 and on page 12, lines 13-15. Furthermore, the description of the drawings states that Figure 5 is a graph of idealized misfit profiles for an optimized DH showing the bulk, unstrained misfit (shown in Figure 5 by the solid line) for the fully relaxed layers, and the strained, in-plane misfit (shown in Figure 5 by the dashed line) as functions of position with respect to the substrate surface using the optimized heterostructure design.

For at least the foregoing reasons, the Examiner has failed to establish that claims 1 and 13 fail to comply with the written description requirement.

<u>Dependent Claims 2-12 and 14-30</u>

Claims 2-12 and 14-30 depend from claims 1 and 13, respectively, which are believed to be allowable. Therefore, claims 2-12 and 14-30 are also believed to be allowable for at least the same reasons as claims 1 and 13.

<u>Rejection under 35 U.S.C. §103(a)</u>

Claims 1-25 and 27-29 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,518,934 to Forrest et al. ("Forrest") in view of U.S. Patent No. 6,229,152 to Dries et al. ("Dries").

Claims 26 and 30 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Forrest in view of Dries and further in view of U.S. Patent No. 6,350,993 to Chu et al. ("Chu").

It is well settled that three basic criteria must be met to support a rejection under 35 U.S.C. §103(a). First, there must be some suggestion or motivation, either

in the references themselves or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art cited must teach or suggest all the claim limitations. *See* M.P.E.P. §2143.

<u>Independent Claim 1</u>

Claim 1 recites "an active layer, wherein a lattice constant of the buffer layer parallel to the substrate is matched to a lattice constant of the relaxed intermediate region to discourage glide of threading dislocations from the strained buffer layer to the active layer." The cited references fail to teach or suggest at least these recitations.

The Examiner relies on layer 27 in Forrest as disclosing these recitations. Figure 5A-5B in Forrest show a structure comprising a substrate 15 followed by a first active layer 9; followed by step-graded layers 21, 23, 25, and 17; followed by a second active layer 11; followed by step-graded layers 18, 27, 29, and 19; followed by a third active layer 13; followed by cap 31. See also col. 3, lines 8-10 where Forrest refers to layer 27 as a step-graded layer. The Examiner admits that there is no disclosure in Forrest that layer 27 is a relaxed intermediate region.

Instead, the Examiner relies on Dries as teaching this recitation. However, Dries teaches strain-compensated quantum wells. Furthermore, although the abstract mentions "mismatched" transition layers, throughout the specification, Dries refers to lattice matched transition layers. See, e.g., col. 2, lines 53-57. Nor does Dries teach an unstrained, relaxed intermediate layer. All Dries discloses is an intermediate or "speedup" layer, disposed between strained multiple quantum wells and strain-compensating layers, that is used only as a buffer to keep the crystalline structure from breaking up.

For at least the foregoing reasons, the Examiner has failed to establish that independent claim 1 is obvious in view of the cited references.

Independent Claim 13

Claim 13 recites "depositing an active layer on the relaxed intermediate region, such that a lattice constant of the buffer layer parallel to the substrate is matched to a lattice constant of the relaxed intermediate region to discourage glide of threading dislocations from the strained buffer layer to the active layer." The cited references fail to teach or suggest at least these recitations as discussed in more detail above for claim 1.

For at least the foregoing reasons, the Examiner has failed to establish that independent claim 13 is obvious in view of the cited references.

Dependent Claims 2-12, 14-25, and 27-29

Claims 2-12, 24-25 and 27 depend from independent claim 1, and claims 24-23 and 28-29 depend from independent claim 13. The independent claims are believed to be allowable. Therefore, the dependent claims are also believed to be allowable for at least the same reasons as the respective independent claims.

Dependent Claims 26 and 30

Claim 26 depends from independent claim 1, and claim 30 depends from independent claim 13. The independent claims are believed to be allowable. Therefore, the dependent claims are also believed to be allowable for at least the same reasons as the respective independent claims.

In addition, claims 26 and 30 further recite "the buffer layer is a compositional overshoot which compensates for residual strain in the buffer layer such that the lattice constant in a growth plane matches that of the relaxed lattice constant of both the intermediate region and the active layer." There is no teaching or suggestion in Forrest or Dries of at least these recitations, as discussed above for the dependent claims. To the contrary, Forrest states that layer 27 does not exactly match that of the absorption layer 11. See, e.g., col. 3, lines 15-17. Instead, the Examiner relies on Chu. However, Chu discloses a spacer layer to separate differently doped layers. See, e.g., col. 7, lines 20-24; col. 9, lines 45-50 and lines 51-61; and col. 10, lines 1-8 and 32-37. Furthermore, Chu is silent as to discouraging dislocation glide.

Conclusion

For the reasons provided herein, Appellant respectfully requests the Board to rule that the rejections of the claims are improper.

Respectfully submitted,

Mark D. Trenner, Reg. No. 43,961
NREL Patent Counsel

Dated: August 15, 2008

National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
(303) 384-7365

VIII. CLAIMS APPENDIX

1. A heterostructure containing semiconductor alloys for minimizing dislocations resulting from lattice mismatch of an active, heteroepitaxial layer, the heterostructure comprising:

a substrate;

a compositionally graded region terminated by a strained buffer layer;

a relaxed intermediate region;

an active layer, wherein a lattice constant of the buffer layer parallel to the substrate is matched to a lattice constant of the relaxed intermediate region to discourage glide of threading dislocations from the strained buffer layer to the active layer; and

a capping layer.

2. The heterostructure of claim 1 wherein the substrate is constructed from InP.

3. The heterostructure of claim 1 wherein the graded region is constructed from $InAs_yP_{1-y}$.

4. The heterostructure of claim 3 wherein the composition within the $InAs_yP_{1-y}$ graded region is varied incrementally thereby accommodating the mismatch of the active layer.

5. The heterostructure of claim 1 wherein the buffer layer is a strained buffer layer constructed from $InAs_yP_{1-y}$.

6. The heterostructure of claim 5 wherein the strained $InAs_yP_{1-y}$ buffer layer is grown to a thickness of approximately one (1) μm.

7. The heterostructure of claim 1 wherein the active layer is constructed from $Ga_xIn_{1-x}As$.

8. The heterostructure of claim 7 wherein the $Ga_xIn_{1-x}As$ active layer is deposited upon the buffer layer.

9. The heterostructure of claim 1 wherein the capping layer is constructed from $InAs_yP_{1-y}$.

10. The heterostructure of claim 9 wherein the $InAs_yP_{1-y}$ capping layer is grown for electrical passivation.

11. The heterostructure of claim 1 wherein the active layer is constructed from epitaxial $Ga_xIn_{1-x}As$ with $x<0.47$, and the graded region and buffer layer are constructed from $InAs_yP_{1-y}$.

12. The heterostructure of claim 1 wherein each of the layers is deposited with a vapor-phase epitaxy technique.

13. A method for eliminating strain and dislocations resulting from lattice mismatch of a heteroepitaxial layer, the method comprising:

providing a substrate;

depositing a compositionally graded region on the substrate;

terminating the graded region with a buffer layer;

depositing a relaxed intermediate region on the buffer layer;

depositing an active layer on the relaxed intermediate region, such that a lattice constant of the buffer layer parallel to the substrate is matched to a lattice constant of the relaxed intermediate region to discourage glide of threading dislocations from the strained buffer layer to the active layer; and

depositing a capping layer on the active layer.

14. The method of claim 13 further comprising: constructing the substrate from InP.

15. The method of claim 13 further comprising: constructing the graded layer from $InAs_yP_{1-y}$.

16. The method of claim 15 further comprising: incrementally varying the composition y of the graded layer thereby accommodating the mismatch of the heteroepitaxial layer.

17. The method of claim 13 further comprising: constructing the a strained buffer layer from $InAs_yP_{1-y}$.

18. The method of claim 17 further comprising: growing the strained $InAs_yP_{1-y}$ buffer layer to a thickness of approximately one (1) μm.

19. The method of claim 13 further comprising: constructing the active layer from $Ga_xIn_{1-x}As$.

20. The method of claim 19 further comprising: depositing the $Ga_xIn_{1-x}As$ active layer upon the buffer layer.

21. The method of claim 13 further comprising: constructing the capping layer from of $InAs_yP_{1-y}$.

22. The method of claim 21 further comprising: growing the $InAs_yP_{1-y}$ capping layer for electrical passivation.

23. The method of claim 13 further comprising: depositing each layer by vapor-phase epitaxy.

24. The heterostructure of claim 1 wherein the graded region is step-graded.

25. The heterostructure of claim 1 wherein substrate is semi-insulating.

26. The heterostructure of claim 1 wherein the buffer layer is a compositional overshoot which compensates for residual strain in the buffer layer such that the lattice constant in a growth plane matches that of the relaxed lattice constant of both the intermediate region and the active layer.

27. The heterostructure of claim 1 wherein the intermediate region includes at least one displacement layer.

28. The method of claim 13 wherein the graded region is step-graded.

29. The method of claim 13 wherein the substrate is semi-insulating.

30. The method of claim 13 wherein the buffer layer is a compositional overshoot which compensates for residual strain in the buffer layer such that the lattice constant in a growth plane matches that of the relaxed lattice constant of both the intermediate region and the active layer.

IX. EVIDENCE APPENDIX

Not applicable.

X. RELATED PROCEEDINGS APPENDIX

Not applicable.